Tuned Feeders and Multiband Antennas

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A radio signal is generated by a standing wave current flowing along the wire in an antenna. This current changes at a sinusoidal rate and the value I in a half wave antenna is shown by curve I in Fig 1. The voltage is shown by curve E. The impedance at any point is E/I and is shown by curve Z. Its value varies from about 70 ohms at the centre to around 3000 ohms at the ends.

The current to excite this standing wave can be fed into the antenna at any point along the wire and the usual way is by a two wire transmission line — a feeder. If the characteristic impedance of the feeder matches the impedance of the wave at the feed point the whole of the feeder current flows into the antenna and all the input power is radiated. If the impedance does not match, a proportion of the current, depending upon the degree of mismatch is reflected back into the feeder and this, together with the forward current, sets up a standing wave in the feeder and reduced power is radiated.

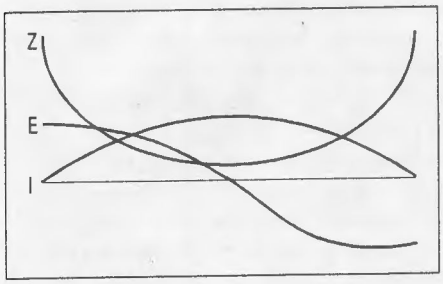

Fig. 1

The standing wave in the feeder is similar to the standing wave in the antenna in that it has high impedance points a half wave apart and midway between these points the impedance falls to a minimum. Thus, somewhere along the feeder, any particular value of impedance can be found and the standing wave in the feeder can be moved up the feeder to make a selected value come to the antenna feed point to match the impedance of the antenna standing wave. When this is done, although reflections still occur, most of the power is eventually fed into the antenna and radiated.

In the example shown in Fig 2 a low impedance point in the feeder has been brought up to the low impedance point in the antenna to make a match. This has been brought about by using a matching device at the feeder input to adjust the impedance at the input to the value a...a shown in Fig 2. The matching device, usually known as an antenna tuning unit (ATU), transforms the impedance of the transmitter output to the required impedance at the feeder input — a...a in this case.

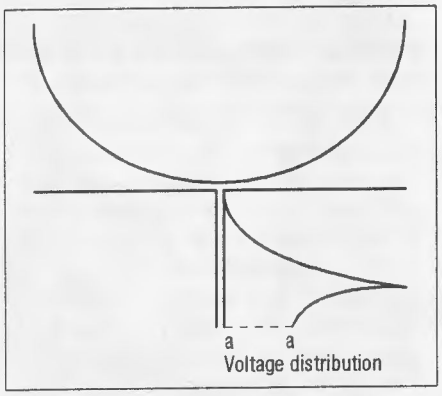

Fig. 2

When tuned feeders are used, the antenna need not be just a half wave long. It can have any length providing that the total length of the antenna plus that of each feeder wire is equal to, or greater than, a half wave at the frequency in use. For example, Fig 3 shows the impedance curves drawn for an antenna 2.6 half waves long with the standing wave impedance of the feeder matched to the standing wave impedance of the antenna at the mid point. The standing wave in the antenna will then move down the feeder as shown and to bring this about the input impedance of the ATU must have the value b...b shown in Fig 3.

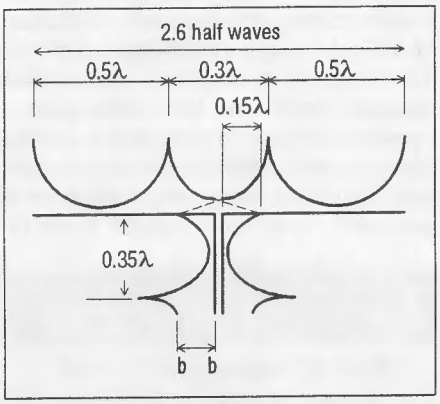

Fig. 3

One type of ATU is shown in Fig 4. This type is the simplest and is easiest to understand and tune. The capacitor tunes the coil to resonance but the match is made by the ratio of the turns on the input coil to the turns between the feeder taps.

If, for example, a 50 ohm transmitter output is to be transformed to a 1000 ohm feeder input the impedance ratio will be 1000/50 = 20 and the turns ratio will be the square root of 20, say 4.5, so that if this ATU input coil has 3 turns, the turns between the taps will be around 14.

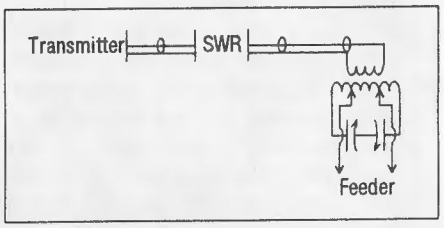

Fig. 4

The above gives a general idea of how a tuned feeder is matched to any antenna and as an example I will describe the setting up of a multiband antenna which I use. The dimensions of this antenna are shown in Fig 5. These dimensions will allow the antenna to fit into most back yards and let the number of ATU taps be reduced because one tap, at the coil ends, will match the 3.5, 7 and 14 MHz bands. For feeders I used 7/.029 wire (because it was available) spaced 51 mm. The ATU used a

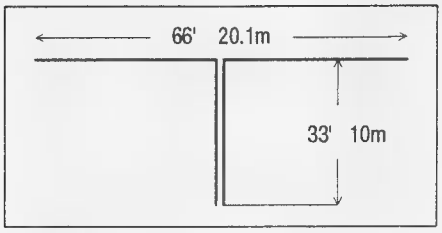

Fig. 5

1930s type broadcast receiver capacitor as the split stator unit. The coil was wound with 16 swg bare copper wire. A length of 2.4 metres was cut off and one end was gripped in the bench vice. The wire was straightened and cleaned with fine sand paper and the free end was hooked into a 2 mm hole drilled in a short length of 3/4 inch water pipe and under maximum tension the coil was close wound walking up to the vice. The coil was removed and light tension was applied between the coil ends until the air space between the turns was 1.5 mm and while the tension was maintained three strips of insulating material approximately 5 mm by 2 mm were glued along the coil with Araldite. A 3 turn input coil was laid over the coil centre but not glued at this time. The coil ends were soldered to the capacitor fixed plate terminals.

To test for the tap points on the coil two wedges were cut from 6 mm square brass rod. They were 25 mm long by 6 mm wide and tapered from a knife edge to 3 mm over the length. Short flexible leads were soldered to the wide ends of the wedges to join them to the feeder ends. One side of the wedges was coated with Araldite so that when they were inserted between the coil turns they made contact with one turn only.

To match the ATU to the feeders it was connected to the transceiver and with the transceiver on receive the taps were inserted across the coil and the dial swung until a noise maximum was heard. A switch was then made to CW transmit and the key held down while making an adjustment for best SWR.

The first setup was made on the 3.5 MHz band and the coil was trimmed so that the band tuned on maximum capacity. When the feeders were connected it was found that, on this band only, the capacity between the feeders added to the tuner capacity and the number of coil turns could be further reduced to 19. This increased the range of the tuner at the high frequency end and the unit was later just able to tune to 28 MHz.

The input coil was then glued into place on the centre of the main coil and the setting of the taps proceeded as follows:

Band	Turns between taps	SWR
3.5, 7, 14, MHz	19	better than 1.05
10 MHz	5	better than 1.05
21 MHz	8	better than 1.05
24 MHz	3	better than 1.05
18 MHz	used tap for 10 MHz	1.5
28 MHz	used tap for 21 MHz	1.5

Permanent connection to the taps was made by soldering leads to the appropriate turn on the coil and taking the leads to banana sockets on the front panel for connection of the feeders. When soldering leads to the coil, adjacent turns were covered with aluminium foil so the solder could only adhere to the chosen turn.

After making this all-band HF antenna I tried the effect of feeding the antenna off centre and set up a similar antenna but with the feeder connected 11 ft from the centre. The results obtained for loading and SWR were the same as for the previous antenna except that the tapping points were different.

If the standing wave current curves for the off-centre fed antenna are drawn it will be seen that the feeder currents are unbalanced (Fig 6) and therefore the feeder will radiate.

A further test was made with the same antenna end-fed and again the antenna loaded fully with SWR close to 1:1 on all bands. The feeder currents would be balanced on 3.5 MHz and its harmonic bands but would be unbalanced on the WARC bands.

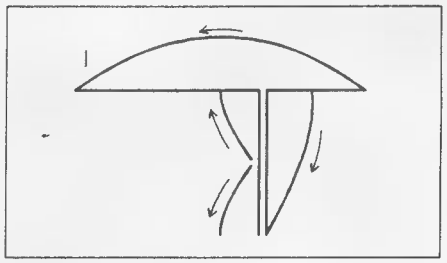

Fig. 6

The unbalance of the feeder currents causes the feeder to radiate. This would affect the radiation pattern but by how much I do not know.

As a result of studying the operation of tuned feeders and making these and other tests my ideas of tuned feeders have changed and I have become aware of some facts that I have never seen in handbooks. These facts are that if the length of antenna plus the length of each feeder wire is greater than a half-wavelength at the frequency concerned almost any combination of antenna length, feeder length, and feed point will function as a workable antenna. For example, I have an antenna used for 21 MHz which has a 22 ft vertical aluminium tube set up on the top of a 30 ft pole and fed by a 24 ft tuned feeder and I have found that it will fully load on 7 MHz and all higher frequencies.

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